OPERATIONS

Operations at a synchrotron light source are key to the success of the scientific endeavors conducted there. Researchers need high-quality photon beams delivered on a reliable schedule in the context of a safe, efficient work environment. Over the years, researchers have come to expect first-rate operations and continuing technological progress at the ALS. In 1996/97, they were not disappointed.

During this period, we increased the beam time available to users, offered a broader range of operating conditions, achieved smaller-than-ever electron beam dimensions (and therefore lower emittance) for routine operations, and enhanced the beam's stability so that users could capitalize on the excellent spatial and spectral resolution that a very-low-emittance beam affords. Moreover, we installed a 2-tesla wiggler to serve as the source for a macromolecular crystallography beamline, installed this beamline and other new beamlines, and completed new facilities to support research in structural biology.

Increased User Access

Since late 1995, when the Scientific Facilities Initiative boosted FY96 funding for the ALS and other DOE national user facilities, we have been able to serve more experiments than ever before. The total number of hours of beam delivered to ALS users in FY96 amounted to 4,461—up 73% from 2,580 hours in FY95.

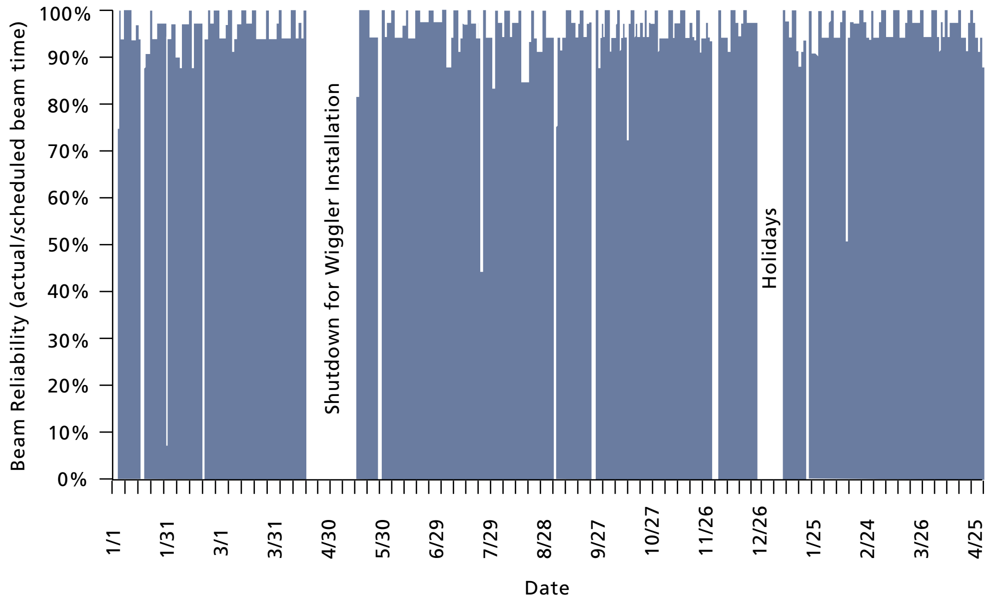
Sixteen 8-hour shifts per week are dedicated to users. Of the five remaining shifts per week, three are assigned to accelerator physics, one is for maintenance and installation activities, and one is for start-up and testing. Other scheduled down time consisted of one two-day period per month for minor maintenance and installation activities and one five-week period in April–May 1996, during which the wiggler was installed. We had no significant unplanned beam outages that resulted in loss of user beam time. Thus, for the period from January 1, 1996, to April 25, 1997, we can boast 89.6% beam reliability (actual/scheduled beam time) during user shifts. If injection periods were included in the users' actual beam time, beam reliability would amount to 94%.

When it comes to scheduling beam time, ALS users have a substantial voice. Scheduling is done at least six months in advance by the users, the Users' Executive Committee, and ALS management; and each week, the schedule for the following two weeks is fine-tuned.

"Customized" Operating Conditions

With its increasing number of beamlines and the concomitant diversity of its scientific program, the ALS is subject to requests for a wide variety of operating conditions. In 1996/97, ALS users had a greater choice than ever before. Operations were conducted at electron beam energies of 1.1, 1.3, 1.5, and 1.9 GeV; however, 1.9-GeV mode was the most common operating mode, as it increases the variety of experiments that can be performed efficiently by providing more usable photon flux at high photon energies. In spring 1997, photon flux was further enhanced when the ALS began operations at 1.9 GeV with the full current of 400 mA.

The ALS also offers several options when it comes to fill pattern (the number and distribution of electron bunches circulating in the storage ring). These include 320 bunch, 304 bunch, 287 bunch, and 2 bunch. In addition, we provide a "camshaft" option, which is a 20-mA spike inserted at the middle of the gap in the 287-bunch fill pattern. The camshaft allows users to synchronize lasers or other instruments with the spike, but does not diminish the photon flux for those using the multibunch fill pattern.



During the period from January 1, 1996, to April 25, 1997, ALS beam reliability (actual/scheduled beam time) was 89.6% during user shifts and 90.0% overall. (If injection periods were included in the users' actual beam time, beam reliability would be 94%.)

Improvements Yield Dividends for Users

We made several hardware and software improvements that benefited the stability and quality of the electron beam and thus the quality of the photon beams delivered to ALS users. In 1995, we had discovered that variations in the temperature of the ALS's low-conductivity water (LCW) supply were the cause of a periodic deviation in the electron-beam orbit. Although we corrected this problem when it was discovered, an overhaul of the LCW system to avoid recurrences became one of our priorities. In 1996, we replaced several components with counterparts that offer better performance. In addition, a cathodic protection system to prevent corrosion was installed on all the LCW water lines connected to the cooling tower.

Also in 1996, we brought our new transverse and longitudinal multibunch feedback systems into routine operation, an improvement that resulted in the smallest electron beam ever available at the ALS for production runs. However, the decreased beam size magnified the importance of some remaining instabilities in the beam's orbit. A task force of physicists and engineers succeeded in identifying the sources of these instabilities. A major source was found to be the temperature regulation of the chilled water supplying the air-conditioning system for the storage ring. Now that this problem has been corrected, we can boast an orbit so stable that its standard deviation is less than one-fourth that stated in the design specifications (see "The Quest to Improve Orbit Stability," p. 34). Among the tools that contributed to this success are new, highly reliable beam position monitors that were installed in eleven of the twelve straight sections around the storage ring.

The 2-tesla wiggler being lowered into position in the ALS storage ring. Its installation was completed in April 1996. The wiggler delivers photons with energies in the 3.5–14 keV range to the new macromolecular crystallography beamline.

A Growing Facility

Only one major shutdown was scheduled during 1996, primarily for the purpose of installing a 2-tesla wiggler into Sector 5 of the storage ring. The fifth insertion device to be added to the ring, the wiggler serves as the source of photons for the ALS's new macromolecular crystallography beamline.

The spectrum and flux of radiation produced by a wiggler depend on the peak field strength of the magnets used in the device. With 38 poles, this wiggler has a peak field strength of 2.1 tesla—more than double that of the ALS bend magnets.

Operating the ALS storage ring at 1.9 GeV improves the flux and brightness even more. For example, at 1 Å (the wavelength conventionally used for macromolecular crystallography), operation at 1.9 GeV yields x rays three times brighter than those produced during 1.5-GeV operation.

The Macromolecular Crystallography Facility is now served by Beamline 5.0, one of four new beamlines that became operational during 1996/97. Researchers who use this beamline benefit not only from the bright x rays generated by the wiggler but also from the new Structural Biology Support Facilities (SBSF) adjacent to the ALS. Completed in

October 1996, these facilities include laboratories, computers for data reduction and visualization, and office space.

Also new is Beamline 7.3.1.2, which delivers x rays with energies in the range 260–1500 eV from a bend magnet. Researchers use it to perform micro x-ray photoelectron spectroscopy studies on materials (see "Micro X-Ray Photoelectron Spectroscopy," p. 40). An infrared microscopy beamline, 1.4, was recently completed for use in chemical mapping studies, including some that could benefit the environment. The fourth new beamline, 12.0.1, delivers x rays from the U8 undulator via two branches. One, which delivers x rays in the energy range 95–130 eV, is designed for conducting spectromicroscopy studies on materials. The other is used in detecting and measuring flaws in reflective optics intended for use in extreme ultraviolet (EUV) projection lithography. The work conducted at this beamline may play a major role in enabling the further miniaturization of integrated circuits, a continuing quest in the electronics industry.

The Structural Biology Support Facilities (SBSF) adjacent to the ALS were completed in 1996. Among the instrumentation at the SBSF is an electron paramagnetic resonance (EPR) spectrometer (left) equipped with a computer console (right). This instrument is used to confirm that samples of metal-containing proteins remain active before and after their exposure to x rays from an ALS beamline. Scientists using the EPR spectrometer want to avoid "doing good physics on bad samples."